IN THE SPECIFICATION:

Please amend paragraph **[0001]** as follows:

[0001] This application is a divisional of application Serial No. 09/640,801, filed August 17, 2000, ~~pending.~~ now U.S. Patent 6,432,752, issued August 13, 2002.

Please amend paragraph **[0013]** as follows:

[0013] In the past decade, a manufacturing technique termed ~~"stereolithography",~~ "stereolithography," also known as "layered ~~manufacturing",~~ manufacturing," has evolved to a degree where it is employed in many industries.

Please amend paragraph **[0024]** as follows:

[0024] In one such stereolithography process, known as "selective laser sintering" or ~~"SLS",~~ "SLS," structures are fabricated from layers of powdered or particulate material. The particles in selected regions of each of the layers can be bonded together by use of a laser under the control of a computer. The laser either heats the material particles and sinters adjacent particles together, heats a binder material mixed in with the particles to bond the particles, or heats a binder material with which the material particles are coated to secure adjacent particles in the selected regions of a layer to one another.

Please amend paragraph **[0025]** as follows:

[0025] Another exemplary stereolithography process that may be used to fabricate substantially hermetic packages incorporating teachings of the present invention is referred to as "laminated object manufacturing" or ~~"LOM".~~ "LOM." Laminated object manufacturing involves the use of a laser or other cutting device to define the peripheries of a layer of an object from a sheet of material. Adjacent layers of the object are secured to one another to form the object.

Please amend paragraph **[0049]** as follows:

[0049] Semiconductor device 10 also includes a substantially hermetic package 20 that completely covers semiconductor die 12, wire bonds 18, and terminals 17 and substantially seals each of these elements to protect same from the environment external to semiconductor device 10. As illustrated, hermetic package 20 extends over the surface of carrier substrate 16 just beyond terminals 17. Accordingly, hermetic package 20 consumes a minimal amount of real estate on carrier substrate 16 and is ~~therefor~~ therefore relatively compact.

Please amend paragraph **[0050]** as follows:

[0050] Hermetic package 20 is preferably formed from a suitable hermetic packaging material, such as a metal, ceramic, or glass. Exemplary types of glass that are most preferred for fabricating hermetic package 20 are thermoplastic glasses, such as those disclosed in United States Patent 5,089,445 (hereinafter "the '445 Patent"), issued to Gaylord L. Francis on February 18, 1992, and in United States Patent 5,089,446 (hereinafter "the '446 ~~Patent),~~ Patent"), issued to Lauren K. Cornelius et al. on February 18, 1992, the disclosures of both of which are hereby incorporated by this reference. The '445 and '446 Patents disclose tin-phosphorus oxyfluoride and lead sealing glasses, respectively. These glasses have sealing temperatures of below about 350° C. and coefficients of thermal expansion (CTEs) of below about $110 \times 10^7 / {}^\circ$ C.

Please amend paragraph **[0051]** as follows:

[0051] FIG. 2 illustrates another embodiment of a semiconductor device ~~10~~ 10′ according to the present invention. Semiconductor device ~~10~~ 10′ includes a semiconductor die 12 flip-chip bonded to a higher level carrier substrate 16. Accordingly, bond pads 14 of semiconductor die 12 are connected to terminals 17 of carrier substrate 16 by way of solder balls ~~18~~ 18′ or other similar conductive structures. Semiconductor die 12, solder balls ~~18 ,~~ 18′, and terminals 17 are substantially hermetically sealed within a hermetic package ~~20 .~~ 20′. As illustrated, hermetic packaging material may fill the space between active surface 15 of

semiconductor die 12 and carrier substrate 16. Alternatively, this space may be filled with an underfill material prior to packaging or the space may remain open.

Please amend paragraph **[0052]** as follows:

[0052] As shown in FIG. 2, the amount of real estate on carrier substrate 16 that is occupied by hermetic package ~~20~~ 20′ is only slightly larger than the amount of real estate occupied by semiconductor die 12. Accordingly, hermetic package ~~20~~ 20′ is relatively compact.

Please amend paragraph **[0053]** as follows:

[0053] Referring now to FIG. 3, another embodiment of a packaged semiconductor device ~~10~~ 10″ according to the present invention includes a leads-over-chip (LOC) type semiconductor die ~~12~~ 12″ and a correspondingly configured lead frame 30. Bond pads ~~14~~ 14″ of semiconductor die ~~12~~ 12″ are electrically connected to corresponding leads 32 of lead frame 30 as known in the art, such as by wire bonds or tape automated bonding (TAB).

Please amend paragraph **[0054]** as follows:

[0054] The hermetic package ~~20~~ 20″ of semiconductor device ~~10~~ 10″ substantially hermetically encapsulates semiconductor die ~~12~~ 12″ in its entirety, as well as the portions of leads 32 that traverse active surface ~~15~~ 15″ of semiconductor die ~~12.~~ 12″. Accordingly, packaged semiconductor device ~~10~~ 10″ may have a relatively small hermetic package ~~20.~~ 20″.

Please amend paragraph **[0055]** as follows:

[0055] Yet another embodiment of a substantially hermetically packaged semiconductor device ~~10~~ 10‴ incorporating teachings of the present invention is depicted in FIG. 4. Semiconductor device ~~10~~ 10‴ includes a semiconductor die 12, the bond pads 14 of which are operably connected to leads 36 of a conventional (i.e., die paddle type) lead frame 34 by wire bonds 38. A hermetic package ~~20~~ 20‴ is disposed over semiconductor die 12 and wire

bonds 38, as well as over portions of lead frame 34 adjacent semiconductor die 12, including the portions of leads 36 proximate wire bonds 38.

Please amend paragraph **[0058]** as follows:

[0058] Turning to FIGs. 1A, 2A, 3A, 4A, and 5A, the illustrated hermetically packaged semiconductor devices 10A,~~10A , 10A , 10A ,~~ 10A′, 10A″, 10A‴, and 110A, respectively, are substantially the same as the hermetically packaged semiconductor device structures illustrated in FIGs. 1, 2, 3, 4, and 5, respectively. Hermetic packages 20A,~~20A , 20A , 20A ,~~ 20A′, 20A″, 20A‴, and 120A are, however, formed from a metal. In addition, hermetically packaged semiconductor devices 10A,~~10A , 10A , 10A ,~~ 10A′, 10A″, 10A‴, and 110A each include electrically insulative coatings, or layers, 21,~~21 , 21 , 21 ,~~ 21′, 21″, 21‴, and 121, respectively, formed over at least the electrically conductive structures of semiconductor devices 12,~~12~~ 12″ so as to insulate the electrically conductive structures from the metal of hermetic packages 20A, ~~20A , 20A , 20A ,~~ 20A′, 20A″, 20A‴, and 120A. These electrically insulative coatings 21,~~21 , 21 , 21 ,~~ 21′, 21″, 21‴, and 121 may also be formed from a hermetic packaging material in accordance with teachings of the present invention, or from a suitable material by other, known methods.

Please amend paragraph **[0065]** as follows:

[0065] As an alternative to the use of a photomask, a hard mask, such as a silicon oxide or silicon nitride hard mask, may be formed on either backside 76 of~~wafer~~ wafer 72 or over active surfaces 15 of semiconductor dice 12. Streets 74 may then be etched through, as known in the art. Such a hard mask need not be removed from wafer 72.

Please amend paragraph **[0072]** as follows:

[0072] The hermetic packages of the present invention are preferably fabricated from a material with good sealing or hermetic properties when applied to a semiconductor die, lead frame, or substrate. Exemplary materials that may be used in the packages of the present

invention include, without limitation, ceramics, metals, and glasses, such as thermoplastic glasses. Of course, if metals are used to form the hermetic packages of the present invention, electrically conductive structures of the packaged semiconductor device should be electrically isolated from the hermetic packaging material to prevent electrical shorting and failure of the semiconductor device. For example, a thin layer of a suitable insulative material, such as glass or ceramic, may be formed over regions of electrically conductive structures of the semiconductor device that will be covered with the hermetic packaging material, as described above with reference to FIGs. 1A, 2A, 3A, 4A, and 5A, respectively. These thin insulative layers 21,~~21 ,~~ ~~21 , 21 ,~~ 21′, 21″, 21‴, and 121 may be formed in accordance with methods of the present invention or otherwise, as known in the art. Preferably, the thin insulative layers 21,~~21 , 21 ,~~ ~~21 ,~~ 21′, 21″, 21‴, and 121 that are used when a hermetic package is formed from a metal also provide hermetic protection to the adjacent regions of the semiconductor device, while the metal hermetic package provides both hermetic protection and robustness.

Please amend paragraph **[0075]** as follows:

[0075] FIG. 15 schematically depicts various components, and operation, of an exemplary stereolithography apparatus 80 to facilitate the reader's understanding of the technology employed in implementation of the method of the present invention, although those of ordinary skill in the art will understand and appreciate that apparatus of other designs and manufacture may be employed in practicing the method of the present invention. Preferred, basic stereolithography apparatus for implementation of the method of the present invention, as well as operation of such apparatus, are described in great detail in United States Patents assigned to DTM Corporation or to Board of Regents, The University of Texas System, both of Austin, Texas, or to The B.F. Goodrich Company of Akron, Ohio, such patents including, without limitation, U.S. Patents 4,863,538; 4,944,817; 5,017,753; 5,132,143; 5,155,321; 5,155,324; 5,156,697; 5,182,170; 5,252,264; 5,284,695; 5,304,329; 5,316,580; ~~5,332,051;~~ 5,342,919; 5,352,405; 5,385,780; 5,430,666; 5,527,877; 5,648,450; ~~5,673,258;~~ 5,733,497; 5,749,041; and

5,817,206. The disclosure of each of the foregoing patents is hereby incorporated herein by this reference.

Please amend paragraph **[0079]** as follows:

[0079] Apparatus 80 includes a horizontal platform 90 on which an object is to be fabricated or a substrate disposed for fabrication of an object thereon. Platform 90 is preferably vertically movable in fine, repeatable increments responsive to computer 82. Material 86 is disposed in a substantially uniform layer of desired thickness by a particulate spreader that operates under control of computer 82. The particulate spreader includes two cartridges 104a and 104b disposed adjacent platform 90 and a roller ~~102 or~~ or scraper 102 bar or blade that is vertically fixed and horizontally movable across platform 90. As a sufficient quantity of particulate material 86 to form a layer of desired thickness is pushed upward out of each cartridge 104a, 104b by a vertically movable support 106a, 106b, respectively, roller or scraper 102 spreads that quantity of particulate material 86 in a uniform layer of desired thickness (e.g., .003 to .020 inches) over platform 90, a substrate disposed thereon, or an object being fabricated on platform 90 or a substrate thereon. Supports 106a, 106b of cartridges 104a, 104b are also preferably vertically movable in fine, repeatable increments under control of computer 82.

Please amend paragraph **[0084]** as follows:

[0084] The size of the laser beam "spot" impinging on the surface of material 86 to consolidate or fix same may be on the order of 0.001 inch to 0.008 inch. Resolution is preferably $\pm$0.0003 inch in the X-Y plane (parallel to surface 100) over at least a 0.5 inch $\times$ 0.25 inch field from a center point, permitting a high resolution scan effectively across a 1.0 inch $\times$ 0.5 inch area. Of course, it is desirable to have substantially this high a resolution across the entirety of surface 100 of platform 90 to be scanned by laser beam 98, such area being termed the "field of ~~exposure",~~ exposure," such area being substantially coextensive with the vision field of a machine vision system employed in the apparatus of the invention as explained in more detail

below. The longer and more effectively vertical the path of laser beam 96/98, the greater the achievable resolution.

Please amend paragraph **[0086]** as follows:

[0086] Once roller or scraper 102 spreads and smooths material 86 into a first thin layer 108 of substantially uniform thickness (for example, .003 to .020 inches) over platform 90 or a substrate disposed thereon, laser 92 directs a laser beam 96 toward ~~galvanometer-mounted mirrors 94,~~ the mirrors of galvanometer 94, which reflect a laser beam 98 toward selected regions of layer 108 in order to affix the particles of material 86 in the selected regions by melting or sintering particles of material 86 to secure adjacent particles of the thermally conductive component of material 86 that are exposed to laser beam 98 to one another. Particles of material 86 in these selected regions of layer 108 are preferably affixed in a regular horizontal pattern representative of a first or lowermost transverse layer or slice of the object to be fabricated, as numerically defined and stored in computer 82. Accordingly, laser beam 98 is directed to impinge on ~~particle~~ particles of first thin layer 108 in those areas where the corresponding layer of the object to be fabricated is comprised of solid material and avoids those areas outside of a periphery of the corresponding layer of the object to be fabricated, as well as those areas of the corresponding layer where a void or aperture exists. Laser beam 98 is withdrawn upon consolidation of material 86 in regions comprising at least the peripheral outline of the corresponding layer of the object being fabricated.

Please amend paragraph **[0087]** as follows:

[0087] With reference to FIG. 17, when material 86 (FIG. 15) in each of the regions of layer 108 (FIG. 15) that correspond to solid areas of the corresponding layer of the object to be fabricated have been exposed to laser beam 98 (FIG. 15), a first particle layer ~~108,~~ 108a (FIG. 17), or first preform layer, is formed. First particle layer ~~108~~ 108a has at least the peripheral outline of the corresponding layer of the object being fabricated at that vertical or

longitudinal level, material 86 within apertures or voids in layer ~~110~~ 108 remaining unconsolidated as loose, unfused particles.

Please amend paragraph **[0088]** as follows:

[0088] Next, platform 90 is indexed downwardly a vertical distance which may or may not be equal to the thickness of the just-fabricated layer ~~108~~ 108a (i.e., a layer-manufactured structure may have layers of different thicknesses). Another layer ~~108~~ 108b of unconsolidated particulate material 86 is then formed over layer ~~108~~ 108a as previously described. Laser beam 98 is then again directed toward selected regions of the new layer ~~108~~ 108b to follow a horizontal pattern representative of a next, higher layer or slice of the object to be fabricated, as numerically defined and stored in computer 82. As each successive layer ~~108is~~ 108 is formed by consolidating material 86 in selected regions, the consolidated material is preferably also secured to the immediately underlying, previously fabricated layer 108. It will be appreciated that, in FIG. 17, the thicknesses of each layer 108 has been exaggerated to clearly illustrate the layered manufacturing process.

Please amend paragraph **[0091]** as follows:

[0091] As an alternative to the use of a laser to sinter or otherwise bond particles of material 86 in the selected regions of each unconsolidated material layer 108 together to form at least partially consolidated layers ~~110,~~ 108a, 108b of an object, an ink jet nozzle or a metal spray gun may be employed as the fixative head. Exemplary apparatus including such fixative heads and exemplary uses thereof are disclosed in the following U.S. Patents: 5,340,656; 5,387,380; 5,490,882; 5,490,962; 5,518,680; 5,660,621; 5,684,713; 5,775,402; 5,807,437; 5,814,161; 5,851,465; and 5,869,170, each of which have been assigned to the Massachusetts Institute of Technology, Cambridge, Massachusetts. The disclosures of each of the foregoing patents are hereby incorporated by this reference. Such a fixative head deposits a liquid binder (e.g., resin or metal) over the particles of material 86 in selected regions of each layer 108, penetrating therebetween and solidifying, thus bonding particles in the selected regions of layer 108 to at

least partially consolidated regions of the next underlying formed layer ~~110.~~ 108a. If an ink jet nozzle is employed as the fixative head, the binder may comprise a nonmetallic binder such as a polymer compound. Alternatively, when a metal spray gun is used as the fixative head, a metallic binder such as a copper or zinc alloy or Kirksite, a proprietary alloy available through Industrial Modern Pattern and Mold Corp., may be employed. In the case of a metal alloy, the binder may be supplied in wire form which is liquified (as by electric arc heating) and sprayed onto the uppermost particulate layer. Another alternative is to liquify the distal end of the binder wire with a laser or other heating means immediately above the unconsolidated powder layer rather than using a metal spray.

Please amend paragraph **[0093]** as follows:

[0093] FIG. 16 illustrates a laminated object manufacturing (LOM) variation of the hermetic package fabrication process of the present invention. LOM employs sheets of material to form an object. As depicted in FIG. 16, an apparatus 200 for effecting the LOM method includes a platform 202, actuating means 204 for moving platform 202 in vertical increments, a sheet feeder 206, a laser head 208, and a control computer 210. Sheet feeder 206 may comprise a photocopier-type feeder and provide individual sheets, or may comprise a roll-type feeder with a feed roller and a take-up roller, as desired. In either case, a sheet 212 of suitable material, such as a thin metal (e.g., copper, aluminum, tungsten, titanium, etc.) or a ceramic or glass sheet, is placed on platform 202. Laser head 208, under ~~control~~ control of computer 210, cuts an outline of the periphery of that layer of the object being fabricated. The surrounding sheet material may then be removed, if desired, and a second, uncut sheet ~~212~~ 212′ placed over sheet 212 is bonded to sheet 212 by suitable means, after which laser head 208 cuts the perimeter outline of the second layer of the object. If desired, the laser may be used to rapidly heat the second sheet ~~212~~ 212′ and bond it to the first sheet 212 before second sheet ~~212~~ 212′ is cut at its periphery. Alternatively, a heated roller 214 may be biased against and rolled over the uppermost second sheet ~~212~~ 212′ to secure the uppermost second sheet ~~212~~ 212′ and the immediately adjacent, underlying sheet 212 to each other before the uppermost second sheet ~~212~~ 212′ is cut to define

the periphery of the corresponding layer of the object being fabricated. The embodiment of FIG. 16 is particularly suitable for substantially concurrently forming a large plurality of hermetic packages on the backside of an unsingulated semiconductor wafer or other large-scale substrate.

Please amend paragraph **[0095]** as follows:

[0095] Referring again to FIG. 15, it should be noted that apparatus 80 useful in the method of the present invention may include a camera 140 which is in communication with computer 82 and preferably located, as shown, in close proximity to galvanometer 94 located above surface 100 of support platform 90. Camera 140 may be any one of a number of commercially available cameras, such as capacitive-coupled discharge (CCD) cameras available from a number of vendors. Suitable circuitry as required for adapting the output of camera 140 for use by computer 82 may be incorporated in a board 142 installed in computer 82, which is programmed as known in the art to respond to images generated by camera 140 and processed by board 142. Camera 140 and board 142 may together comprise a so-called "machine vision system" and, specifically, a "pattern recognition system" (PRS), operation of which will be described briefly below for a better understanding of the present invention. Alternatively, a ~~self-contained~~ self-contained machine vision system available from a commercial vendor of such equipment may be employed. For example, and without limitation, such systems are available from Cognex Corporation of Natick, Massachusetts. For example, the apparatus of the Cognex BGA Inspection Package™ or the SMD Placement Guidance Package™ may be adapted to the present invention, although it is believed that the MVS-8000™ product family and the Checkpoint® product line, the latter employed in combination with Cognex PatMax™ software, may be especially suitable for use in the present invention.

Please amend paragraph **[0097]** as follows:

[0097] Of course, apparatus 200 depicted in FIG. 16 could also be equipped with such a machine vision system.

Please amend paragraph **[0100]** as follows:

[0100] Continuing with reference to FIGs. 15 and 17, a substantially uniform layer 108 of material 86 is disposed over wafer 72 or the one or more semiconductor dice 12 or other substrates on platform 90 to a depth substantially equal to the desired thickness of a formed layer ~~110~~ 108 of hermetic package 20.

Please amend paragraph **[0101]** as follows:

[0101] Laser 92 is then activated and scanned to direct beam 98, under control of computer 82, toward specific locations of surface level 88 relative to each semiconductor device 10 or other substrate to effect the aforementioned partial cure of material 86 to form a first layer ~~110a~~ 108a of each hermetic package 20. Platform 90 is then lowered and another layer 108 of material 86 of a desired thickness disposed over formed layer ~~110.~~ 108a. Laser 92 is again activated to add another layer ~~110b~~ 108b to each hermetic package 20 under construction. This sequence continues, layer by layer, until each of the layers ~~110~~ 108 of each hermetic package 20 have been completed. As illustrated, layers ~~110~~ 108 are first formed laterally adjacent edges of a semiconductor die 12 or other substrate, then over one of the major surfaces thereof (e.g., active surface 15 or back side 13). Each semiconductor die 12 or other substrate is then inverted on platform 90 and the remaining layers ~~110~~ 108 of hermetic package 20 are formed. Of course, a portion of hermetic package 20 may be prefabricated and disposed on platform 90 prior to the disposal of one or more semiconductor dice 12 thereon. Other stereolithographic fabrication sequences for hermetic packages 20 are, of course, also within the scope of the present invention.

Please amend paragraph **[0102]** as follows:

[0102] In FIG. 17, the first, bottommost layer of hermetic package 20 is identified by numeral ~~110a,~~ 108a, and the second layer is identified by numeral ~~110b.~~ 108b. As illustrated, hermetic package 20 has only a few layers ~~110.~~ 108. In practice of the invention, however, hermetic packages 20 may have many thin layers ~~110.~~ 108. Accordingly, hermetic packages 20 with any number of layers ~~110~~ 108 are within the scope of the present invention.

Please amend paragraph **[0103]** as follows:

[0103] Each layer ~~110~~ 108 of hermetic package 20 may be built by first defining any internal and external object boundaries of that layer with laser beam 98, then hatching solid areas of that layer of hermetic package 20 located within the object boundaries with laser beam 98. An internal boundary of a layer may comprise a portion, a void or a recess in hermetic package 20, for example. If a particular layer includes a boundary of a void in the object above or below that layer, then laser beam 98 is scanned in a series of closely spaced, parallel vectors so as to develop a continuous surface, or skin, with improved strength and resolution. The time it takes to form each layer ~~110~~ 108 depends upon the geometry thereof, the surface tension and viscosity of material 86, and the thickness of that layer.